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Measuring Willingness-To-Pay for Risk Reduction: An Application of Conjoint Analysis

Harry Telser and Peter Zweifel*

Abstract

This study applies conjoint analysis (CA) to estimate the marginal willingness-to-pay (MWTP) of elderly individuals for a reduction of the risk of fracture of the femur. The good in question are hypothetical hip protectors which lower the risk of a fracture by different amounts. Other attributes are ease of handling, wearing comfort, and out-of-pocket cost. Thus, the novelty of the present work lies in its letting risk reduction be traded off against several attributes. In 500 face-to-face interviews, pensioners stated whether or not they would buy the product.

Results suggest that MWTP for wearing comfort exceeds that for risk reduction. Indeed, willingness-to-pay for the product as a whole is negative, indicating that it should not be included as a mandatory benefit in health insurance.

JEL classification: C25, D61, D81, H43, I18

Keywords: Conjoint Analysis, Risk Reduction, Willingness-To-Pay

1 Introduction and overview

Estimates of marginal willingness-to-pay (MWTP) for risk reduction are of great importance for health policy. An important class of interventions is of the preventive type in the sense that the probability of illness is affected. Traditionally, the means for such measures have come from sources not incorporated in the health budget. Thus, a first use of estimates of willingness-to-pay (WTP) for risk reduction is to help in structuring the public budget across these traditional divisions. Second, within the health domain, an insurer may want to trade off preventive against curative benefits when defining its benefits. Since insureds cannot be forced to take advantage of preventive offers made available by the insurer, considerations of relative effectiveness need to be complemented by WTP estimates indicating whether individuals at risk will actually take advantage of these offers.

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The present study relates to this second use of WTP measurement. The product in question is a hip protector, i.e. a protective shell worn along with underwear that prevents fracture of the neck of the femur in the event of a fall. One might argue that prevention of falls should take precedence among elderly individuals; however, prevention programs have proved ineffective so far (cf. *Gillespie et al.*, 1997). This leaves prevention of fracture of the femur, which constitutes a major cause of hospitalization, frequently followed by a loss of autonomy and transfer to a nursing home (cf. *Sattin et al.*, 1990; *Cöster et al.*, 1994; for Switzerland: *Hubacher and Ewert*, 1997). The issue is whether a hip protector should be included in the benefit package of social health insurance, and if so, whether it should be exempt from cost sharing. Moreover, given that lack of interest in a preventive measure may be caused by insufficient information, the question arises as to the precise scope and content of the additional information to be provided.

For determining the WTP for such an innovation, two main instruments are available, contingent valuation (CV) and conjoint analysis (CA). Undoubtedly CV is the standard procedure, typically in the form of closed-ended questions that state an amount to be paid and leave it to respondents to indicate whether they would be willing to pay that amount (cf. *Mitchell and Carson*, 1989; *Portney*, 1994). In CV, the only aspect of the scenario allowed to change is the risk of ill health; the respondent is expected to keep the other attributes of the scenario constant and to aggregate the shadow prices of these attributes to a total value to be compared to the stated amount. Such a mental experiment may prove very challenging to many individuals, however. In actual choice situations it is very rare for only one attribute to change whereas all the others remain constant. Developed for market research (cf. *Green and Rao*, 1971), CA seeks to ease the burden of the respondent in three ways. First, the experimenter establishes the relevant attributes of the good or service in question (cf. *Ryan*, 1995, p. 248f.). This list of attributes provides a checklist of important aspects that should be accounted for in decision making. In the case of a hip protector, this may be the inconvenience of wearing and unfavorable appearance of the person. Second, CA calls forth a series of explicit trade-offs between attributes. In this way, shadow prices of attributes are elicited, which facilitates the aggregation to a total value by the respondent. Third, the set of attributes to be held constant across scenarios is always well defined.

There are five stages in the design of a CA study (cf. *Ryan*, 1995; or *Backhaus et al.*, 1996). In the first stage the key characteristics of the service or good in question are identified. This can be done using literature reviews, discussions, or a pretest with individual interviews.

In the second stage levels must be assigned to attributes. The levels should be plausible, actionable and capable of being traded off. However, the number of possible scenarios increases exponentially as the number of attributes and levels increases. Accordingly, in stage 3 the possible scenarios are reduced to a number the respondent can cope with. In stage 4 preferences for the scenarios are obtained by surveying individuals. There are three different methods used in the questionnaire design: ranking, rating, or discrete choice between scenarios. Finally, the data is analyzed (stage 5). A utility function specifying the relationship between the attributes is estimated. It permits to establish the relevance of individual attributes, the marginal rates of substitution between them, and the overall utility derived from the good as a whole. If the cost of the product or service is included as an attribute, WTP can be directly estimated.

In market research respondents are usually asked to establish a ranking of alternatives or even rate them cardinally. In economic applications researchers seek to go in the direction of revealed preference by merely asking for comparisons between pairs of scenarios (cf. *Ryan*, 1995; *Ben-Akiva and Lerman*, 1985; however, see also *Johnson et al.*, 1998). In the present study the choice of scenarios boils down to a stated intention to purchase or not to purchase the product (with the reference scenario given by the status quo), moving it still closer to everyday decision situations.

Up to the present, a reduction of risk has rarely figured among the attributes included in CA. Early applications of CA to morbidity risk are *Magat et al.* (1988) and *Viscusi et al.* (1991); for a more recent contribution, see *Gegax and Stanley* (1997). However, all of these studies limit the variation of characteristics to the risk dimension, which makes them similar to CV analysis. The novel feature of the present study is that risk reduction is traded off against three other attributes (including out-of-pocket cost), permitting to estimate MWTP for each attribute as well as WTP for the entire product. Moreover, predictions suggested by economic theory are tested to assess the validity of CA as a method for estimating WTP for risk reduction.

The plan of the paper is as follows: section 2 is devoted to theoretical underpinnings. In particular the indirect utility function in a Lancaster framework is derived. The data base is reported in section 3, where the relevant product attributes are also defined. Section 4 contains a series of specification tests, specifically addressing the linear scaling of product attributes and the form of the indirect utility function. The results are discussed in section 5, where it is found that the MWTP for risk reduction may well increase with income and initial risk, confirming standard economic predictions. However, average WTP for a hip protector turns out to be negative. The policy implications of these findings are discussed in the final section.

2 Theoretical background

Conjoint Analysis is derived from Lancaster‘s theory of demand (*Lancaster*, 1971), which posits that the consumer values the quantity of product attributes at his disposal through the purchase of a commodity. Thus, the utility function is given by

$$U_t = U(\boldsymbol{Z}_t)$$

where $\boldsymbol{Z}_t$ is a vector of the attribute values for alternative t from the choice set C at the disposal of the decision maker considered. In the present context, risk reduction is equivalent to one particular element of the attribute vector. Therefore, an indifference curve in attribute space indicates the willingness to sacrifice a valued attribute (or accept more of a bad attribute) in exchange for risk reduction. It can be shown that the properties of this indifference curve are largely the same as those of an indifference curve derived from expected utility theory, where the willingness to pay for a risk reduction is expressed in terms of a sacrifice of income. Thus, predictions derived from expected utility theory will be used in section 5.1 to assess the validity of CA as a method for eliciting willingness-to-pay in this particular context.

A point of such an indifference curve corresponds to the maximum attainable utility $U(\boldsymbol{Z}_t^*)$ under alternative t. In the indirect utility function V_t, income Y and price p_t determine the number of units x_t of the good that can be purchased; x_t times the per unit quantity of an attribute z_t then gives the total quantity of an attribute Z_t. Therefore, the indirect utility function in a Lancaster framework may be written,

$$V_t = V(\boldsymbol{z}_t, p_t, Y) = U(Z_t^*) .$$

The marginal rate of substitution between two attributes m and n is given by

$$\mathrm{MRS} = -\frac{\partial V_t / \partial z_{tm}}{\partial V_t / \partial z_{tn}} . \tag{2.1}$$

One of the product attributes may be price (p_t). Denoting the n-th attribute as price, Eq. (2.1) indicates the MWTP for attribute m.

In empirical applications a vector of socioeconomic characteristics $\boldsymbol{S}$ is introduced into the function reflecting the variability of tastes across the portion of the population to which the model of choice behavior applies (cf. *Ben-Akiva and Lerman*, 1985), resulting in

$$V_t = V(\boldsymbol{z}_t, p_t, Y, \boldsymbol{S}).$$

The individual is always assumed to select the alternative with the highest utility. However, to the observer the utilities are not known with certainty and are therefore treated as random variables. Accordingly, the choice probability of alternative t is equal to the probability that the utility of alternative t, V_t, is greater than or equal to the utility of alternative s:

$$\Pr(t) = \Pr[V_t > V_s] \tag{2.2}$$

where $\Pr(t)$ is the probability of the decision maker choosing alternative t.

In general, the random utility of an alternative can be expressed as a sum of observable (or systematic) and unobservable components of total utilities:

$$V_t = W(\boldsymbol{z}_t, p_t, Y, \boldsymbol{S}) + \varepsilon_t \equiv W_t + \varepsilon_t, \tag{2.3}$$

and Eq. (2.2) can be rewritten as

$$\Pr(t) = \Pr[W_t + \varepsilon_t > W_s + \varepsilon_s] = \Pr[W_t - W_s > \varepsilon_s - \varepsilon_t]. \tag{2.4}$$

To derive a specific random utility model, we require an assumption about the probability distribution of the disturbance, $(\varepsilon_s - \varepsilon_t)$. Assuming that $\varepsilon_s - \varepsilon_t$ has a standard normal distribution, probit can be used for estimation of $\Pr(t)$. Note that (assuming the indirect utility function to be additively separable) determinants of W that do not differ between scenarios s and t (in particular Y and $\boldsymbol{S}$) drop out of the equation.

In the present context, the purchase decision is about whether to buy a hip protector or not. The product attributes of such a hip protector are assumed to be protective effect, wearing comfort, ease of handling, and change of appearance, with out-of-pocket cost singled out. Utility (and therefore the likelihood of intent to purchase, referred to as ’purchase decision’ henceforth) should be increasing in the attributes ’protective effect’, ’wearing comfort and ease of handling’; it should be decreasing in the attributes ’out-of-pocket cost’ and ’change of appearance’.

3 Data

Following a pretest, more than 500 personal interviews with individuals aged 70 and older were conducted at their homes in the Summer of 1998. Socioeconomic characteristics include age, sex, housing, education, income, dieting efforts, fitness and sportive activities. The questionnaire also covered subjective health, previous fracture of the femur, falls, fear of falls, and general preventive behavior.

The attributes of the hip protector were tested for their relevance in a pretest. It turned out that the dimension 'appearance' was judged unimportant by a clear majority. Moreover, interviewers reported that 'ease of handling' and 'wearing comfort' constitute two different attributes. Product price was deemed very important by a majority, with few refusals. This is amazing because Swiss social health insurance has a very comprehensive benefit package; this may make individuals believe that health care services are costless. Therefore, it had to be expected that respondents would refuse answering this question, pointing out that hip protectors should be offered free of charge. The importance of the retained product attributes was again ascertained in the field survey. As shown in Table 3.1, a majority of respondents judged all of the four attributes to be very important. In view of the much more clearcut results of the pretest and the marked gap between 'appearance' and the other four attributes, deleting this dimension from the purchase decision can be justified.

Table 3.1 Relevance of product attributes

Attribute	mean importance[a)]	very important	not important
Protective effect	1.57	63%	7%
Ease of handling	1.37	73%	3%
Wearing comfort	1.46	67%	4%
Appearance	2.10	37%	13%
Out-of-pocket cost	1.78	50%	7%

Note:[a)] mean of four categories (very important=1; quite important=2; little important=3; not important=4)

The retained attributes 'protective effect' (PROT), 'ease of handling' (HAND), 'wearing comfort' (COMF), and 'out-of-pocket cost' (COST) jointly define a number of scenarios. Since the first three have 3 levels each, while COST has 4, this number amounts to a total of 108 (=3*3*3*4) possible scenarios. Obviously, it would not be feasible to present each scenario separately and get respondents to state their preference. Techniques have been developed to reduce the number of possible scenarios while still being able to infer utilities for all combinations of levels of the attributes (*Backhaus et al.*, 1996; *Addelman*, 1962). Using the ORTHOPLAN procedure programmed in the software package SPSS, the design was reduced to 23 scenarios. These 23 variants were split in two lists featuring a different sequence of presentation of the hip protectors to avoid boredom and bias on the part of respondents. With regard to each variant, respondents had to indicate whether or not they would buy the product (PURCHASE). In view of the fact that these individuals still live independently in their homes, which requires good health, it had to be expected that interest in the hip protector would be rather limited. Thus, the group selected poses a challenge because their MWTP for risk reduction is likely to be small or non-existent.

Concerning the problem of non-response, the relative simplicity of CA should be reflected in a low rate of refusals to answer the pertinent questions. Indeed, the purchase decision question had a low rate of non-response (4 individuals). However, particular items are associated with a higher rate of refusal, viz. income (roughly 50%).

In Table 3.2, descriptive statistics with regard to the dependent and explanatory variables are reported. With a mean of 0.22, the dependent variable PURCHASE is somewhat clustered. The hip protector is represented by four product attributes. A higher value corresponds to better protective effect, more ease of handling and wearing comfort, and more out-of-pocket cost. The remaining variables represent income, education, and initial risk. With a monthly income of about 2,627 Swiss francs (US$1,751 at 1999 exchange rates), the sampled individuals are below the average. Education is measured by two dummy variables, indicating that there are very few individuals with high education in the sample. Women make up two-thirds of the sample, and average age is 79. With the exception of the experience of a fracture of the femur which is a dummy variable, the remaining variables have several categories. A higher value indicates that the individual is healthier (HEALTH), invests more in prevention (FOOD, FITN), and experienced more falls (FALLS) within the last 12 months. It can be seen that prevention through fitness, experience of a fracture of the femur (FRACT), and frequency of falls cluster in the lowest category. On the other hand, health status is high (around 4 with a maximum of 5) for a sample of individuals with average age of 79, confirming the view that they constitute a positive selection. Very likely this lowers MWTP for risk reduction and WTP for the entire product.

Table 3.2 Descriptive statistics of the variables

Variable	Label	Median	Mean	Std. Dev.	Min	Max
Purchase decision (Dummy)	PURCHASE	0	0.22	0.411	0	1
Protective effect	PROT	75	79.10	19.125	50	100
Ease of handling	HAND	2	2.16	0.779	1	3
Wearing comfort	COMF	2	2.19	0.746	1	3
Out-of-pocket cost (Swiss francs)	COST	75	91.94	80.258	0	200
Age	AGE	79	79.32	5.845	70	96
Sex (Dummy)	SEXM	0	0.29	0.452	0	1
Income of individual (100 Swiss francs)	INCOME	15	26.27	11.612	2.5	80
Low Education (Dummy)	EDUL	0	0.35	0.476	0	1
High Education (Dummy)	EDUH	0	0.08	0.277	0	1
Health status	HEALTH	4	3.72	0.855	1	5
Prevention through diet	FOOD	2	3.08	3.138	0	11
Prevention through fitness	FITN	0	1.24	1.623	0	5
Ability to walk	WALK	3	3.12	0.873	1	4
Frequency of falls in the last 12 months	FALLS	1	1.48	0.834	1	4
Experience of a femur fracture (Dummy)	FRACT	0	0.08	0.265	0	1

Conjoint analysis is designed to mirror everyday choices, which are between products of well-defined but varying attributes and prices. Accordingly, the questionnaire also contained an item concerning the ease with which the purchase questions were answered. A considerable majority (71%) indicated that it was easy or very easy to make the decisions. Again, this result was not necessarily expected in a sample of individuals of high age.

Conclusion 3.1: In view of the age bracket addressed, the field survey was successful in eliciting responses to a series of purchase questions that were of acceptable difficulty for participants.

4 Specification tests

In this section, three specification tests are reported. The first concerns the scaling of the variables reflecting product attributes. The second is devoted to the choice of utility function. Finally, the derivation of the final model is documented.

Since each respondent had to value 11 or 12 different hip protectors, the data are of the panel type. For this reason, a random effects probit specification is used, assuming responses of a given individual to purchase questions to be correlated, while answers provided by different individuals to be uncorrelated.

4.1 Scaling of product attributes

The scaling issue concerns three product attributes, the protective effect of hip protectors (PROT), their handling (HAND), and comfort in wearing (COMF). The discussion will focus on PROT, dealing with HAND and COMF more concisely.

The protective effect of hip protectors was scaled using three values in the survey, with the risk of fracture of the femur being reduced by 50%, 75%, and 100%. However, a linear representation of product attributes would simplify the calculation of MWTP values considerably. Therefore, two tests for linearity were set up. First, a Wald test was used to test for linearity of the coefficients of a dummy variable representation of PROT. Second, the model including PROT as dummy variables was compared to a model with a linear specification of PROT, using a likelihood-ratio test.

The evidence suggests that a linear representation of PROT is compatible with the data, as the effect of a risk reduction from 0% to 50% cannot be statistically distinguished from the reduction from 50% to 100%. Also, a risk reduction from 50% to 75% and one of 50% to 100% have effects close to 1:2 according to the data. Therefore, the linear representation of PROT may be retained, permitting the construction of an average value of PROT and hence the calculation of MWTP at the sample means.

The same tests for linearity were used for the product attributes handling and wearing comfort. Results clearly suggest that a linear representation of HAND and COMF is compatible with the data.

4.2 Choice of utility function

The conclusion reached in the preceding section is still conditional on a linear indirect utility function being an acceptable approximation to the true one. A popular alternative is the quadratic utility function (cf. *Peckelman and Sen*, 1979). In view of the orthogonal design imposed, the utility function to be tested contained no interaction terms (cf. *Gegax and Stanley*, 1997). Results indicated that the quadratic terms were not significant at conventional levels, with the one exception of cost. However, the estimated coefficient of $(\text{COST})^2$ turned out so small as to make the linear alternative, evaluated at the mean cost, undistinguishable from the quadratic. A likelihood ratio test indicated that the exclusion of all quadratic terms does not entail a significant loss of explanatory power. Therefore, an indirect utility function linear in product attributes seems to serve as a sufficient local approximation to its true counterpart (which merely needs to be quasiconvex in price).

4.3 Derivation of final model

Up to this point, the specification tests involved only the product attributes because individual characteristics should be irrelevant in the choices analyzed. The hypothesis that the marginal valuation of product attributes should be the same across scenarios receives support from the left hand side of Table 4.1, where the great majority of the relevant coefficients lack statistical significance.

The performance of the income variable is of particular importance in this context. A test of its significance in the regression produces a *z*-value of -1.06, indicating that income does not influence the decision to purchase a hip protector. Dropping INCOME from the list of regressors has two major advantages. First, since this variable had missing values in 50 percent of the cases, sample size nearly doubles, permitting more precise statistical inferences. Second, retaining only observations with income reported could have been the cause of sample selection bias. With income irrelevant, there is no need to exclude observations from the usable sample, implying that the selection problem loses its relevance. As shown on the right hand side of Table 4.1, the remaining individual characteristics lack statistical significance as well under these conditions. This finding is in agreement with theoretical predictions.

Thus, the final model (shown in Table 4.2) contains only the four product attributes in linear form, including cost. All coefficients are highly significant, and their signs conform to theoretical predictions. Finally, the dispersion indicator says that almost 90 percent of the time (see also the out-of-sample test of section 5.3) predicted and actual choices coincide.

5 Results

In this section, MWTP for risk reduction is calculated and differences for sample segments are reported, using the estimates of the final model as presented in Table 4.2. Such differences are

Table 4.1 Random effects probit estimates for the full model

	Full Model (restricted sample)				Basic Model (comprehensive sample)			
Variable	Coef.		Std. Err.	z	Coef.		Std. Err.	z
PROT	.0128246	***	.0015846	8.093	.01363	***	.0013053	10.442
HAND	.3147707	***	.0398394	7.901	.3384189	***	.0325778	10.388
COMF	.6567862	***	.0439779	14.934	.6669272	***	.0369512	18.049
COST	-.0029445	***	.0003692	-7.975	-.0030195	***	.0003015	-10.015
AGE	-.0147902		.0092732	-1.595	-.0103517		.0073904	-1.401
SEXM	.099162		.1260012	0.787	-.0131725		.0989818	-0.133
INCOME	-.0039477		.0037135	-1.063				
EDUL	-.2324119	*	.1150624	-2.020	-.097488		.0935865	-1.042
EDUH	.1429914		.1753311	0.816	.0806202		.1559256	0.517
WALK	-.1597966	*	.0661918	-2.414	-.1011283		.0555153	-1.822
FOOD	.0277863		.0162832	1.706	.0201882		.0134713	1.499
FITN	-.0810628	*	.0335979	-2.413	-.0407727		.0266574	-1.530
HEALTH	.0308547		.0748892	0.412	.0114358		.0564693	0.203
FRACT	-.4430768	*	.2113526	-2.096	-.1186491		.1702213	-0.697
FALLS	-.0619443		.0695411	-0.891	.0156207		.0526188	0.297
CONST	-1.95775	*	.8803808	-2.224	-2.853549	***	.7003044	-4.075
Number of obs.	= 2341				= 3505			
$chi^2(15)$	= 354.84				= 541.00			
Prob > chi^2	= 0.0000				= 0.0000			
Deviance	= 2150.72				= 3101.29			
Dispersion	= 0.9250417				= 0.888620			
ρ	= 0.1787				= 0.1810			

* (**, ***)Coefficient different from zero with an error probability of 5% (1%, 0.1%)

of interest from two points of view. First, they provide a test of standard theoretical predictions. Second, from a policy perspective one may want to identify groups whose MWTP for risk reduction is particularly high.

5.1 Results of theoretical interest

The calculation of MWTP for risk reduction is based on Eq. (2.1). Since the indirect utility function is linear in its arguments, the marginal rate of substitution between the protective

Table 4.2 Random effects probit estimates for the final model (comprehensive sample)

Variable	Coef.		Std. Err.	z	P>|z|
PROT	.0140928	***	.0012657	11.135	0.000
HAND	.3325371	***	.0313347	10.612	0.000
COMF	.6627655	***	.0360715	18.374	0.000
COST	-.0029297	***	.0002901	-10.100	0.000
CONST	-3.981261	***	.1868118	-21.312	0.000
Number of obs.	= 3714		Deviance	= 3269.53	
$chi^2(15)$	= 569.31		Dispersion	= 0.8815125	
Prob > chi^2	= 0.0000		ρ	= 0.1879	

* (**, ***)Coefficient different from zero with an error probability of 5% (1%, 0.1%)

effect (i.e. the reduction of risk) and the price of a hip protector amounts to a division of the regression coefficient pertaining to PROT by the coefficient pertaining to COST. MWTP turns out to be $4.81 (=0.01409/0.00293)$ Swiss francs, equivalent to US$3.21 per percentage point of risk reduction.

One standard prediction is that individuals with a higher income should have a higher MWTP for lowering risk (cf. *Zweifel and Breyer*, 1997, ch. 2). However, income is one of the personal characteristics that should not influence the purchase decision, as argued in sections 2 and 4.3. This does not preclude income modifying the marginal valuation of product attributes, thus affecting the marginal rate of substitution between them. Therefore, MWTP for risk reduction may still be increasing in income. This presumption can be verified by estimating the model for different subsamples (cf. *Ryan*, 1995, p. 261f; *Ben-Akiva and Lerman*, 1985, p. 194f; an alternative approach is to include interaction terms). Thus, the purchase equation was estimated separately for low and high incomes. Indeed Table 5.1 shows that MWTP for risk reduction is positively related to income, a result in accordance with theoretical predictions.

Table 5.1 MWTP for risk reduction according to income, per percentage point

Income (US$ per month)	MWTP for risk reduction (US$)	Standard Error
0 to 2,000	2.49	0.50
2,000 and more	5.00	1.55
overall	3.21	0.41

Another variable that should be unambiguously related to MWTP for lowered risk is initial risk π (cf. again *Zweifel and Breyer*, 1997, ch. 2). While π cannot be measured directly, there are several indicators of it. AGE and FALLS reflect personal characteristics; FITN and FOOD, preventive effort. FITN points to efforts that are targeted at the prevention of falls; therefore it should be directly related to π. In the case of FOOD, however, preventive effort is directed at health in general, making this indicator a less informative one with regard to π. Gender, defining unambiguously a potential target group for intervention, is taken up in the next subsection.

When using AGE as the indicator of π, the theoretical prediction is that MWTP should increase with age because π strongly increases with age (cf. *Sattin et al.*, 1990; *Cöster et al.*, 1994; for Switzerland: *Hubacher and Ewert*, 1997). As Table 5.2 shows, this prediction is largely borne out, although the overall increase is not statistically significant according to conventional significance levels. Thus, an individual aged 85 and more is prepared to pay some US$4.4 per percentage point of risk reduction. For such an individual, a hip protector offering complete protection cet. par. would have a value of US$218 over a model offering only 50 percent protection. However, other product attributes may turn WTP for the product as a whole into a negative value, as shown below.

Table 5.2 MWTP for risk reduction according to age, per percentage point

Age	MWTP for risk reduction (US$)	Standard Error
70 - 75	2.82	0.62
76 - 80	3.95	1.26
81 - 85	3.64	0.96
85 +	4.39	1.39
overall	3.21	0.41

Finally, FALLS might constitute an objective indicator of risk. However, an increasing number of previous falls was not related at all with the MWTP for risk reduction.

With regard to prevention, the indicator FITN clusters so strongly in one response category (no effort for fitness) that its effect on MWTP can only be identified w.r.t. two samples of respondents, viz. individuals with and without preventive effort. For the other prevention variable FOOD, a segmentation into four categories is possible. The two indicators turn out to be negatively related to MWTP for risk reduction (cf. Table 5.3). Apparently, the more preventive effort an individual undertakes (hence lowering the initial risk π), the less he or she is willing to pay for risk reduction.

Table 5.3 MWTP for risk reduction according to prevention, per percentage point

Prevention through fitness	MWTP for risk reduction (US$)	Standard Error
no prevention	3.68	0.57
preventive effort	2.54	0.59
Prevention through diet		
no prevention	5.93	1.46
little preventive effort	4.55	1.51
some preventive effort	2.57	0.67
great preventive effort	1.58	0.49
overall	3.21	0.41

Conclusion 5.1: Based on final model estimates, there is limited evidence suggesting that increased income and initial risk go along with a higher MWTP for risk reduction, as predicted by theory. This speaks in favor of the validity of Conjoint Analysis as a method for measuring willingness-to-pay for risk reduction.

5.2 Results of policy relevance

For policy purposes, easy observability of variables determining MWTP and WTP for the product as a whole is of prime importance. On this account, AGE, SEXM, EDUL and EDUH and possibly INCOME qualify. Differences in MWTP for risk reduction according to age were discussed in the previous section, where age was interpreted as an indicator of initial risk. At this point, gender differences are taken up with a view on policy. In the relevant literature it is an established fact that women are roughly twice as likely to suffer a fracture of the femur than men (*Johnell et al.*, 1984; for Switzerland: *Hubacher and Ewert*, 1997). To the extent that women are aware of this difference, they should exhibit a higher MWTP for risk reduction then do men, suggesting that they might contribute a designated group for policy intervention. However, Table 5.4 shows that MWTP of women is substantially less than that of men. Detailed analysis of the data shows that those (few) women with high incomes exhibit a higher MWTP than do men at that same income. These observations are compatible with the view that women in the lower income groups have an information deficit with regard to risk. This should be taken into due account in any campaign designed to prevent fracture of the femur.

Table 5.4 MWTP for risk reduction according to sex, per percentage point

Sex	MWTP for risk reduction (US$)	Standard Error
male	4.73	1.12
female	2.77	0.44
overall	3.21	0.41

An interesting question from the policy point of view is the amount of WTP for the product as a whole. Only if $WTP > 0$ can one expect a purchase of the hip protector; however, this does not guarantee that it will actually be worn. Conversely, if $WTP < 0$ then the protector will neither be purchased nor used. Assuming that the final model is correctly specified (see section 4), the constant may be interpreted as indicating a basic preference for the product. From this benchmark, one may integrate the MWTP over the four attributes distinguished to obtain WTP for the product as a whole. As shown in Table 5.5, a protector having average features with regard to each of the three attributes distinguished evokes a negative WTP. It takes a protector with the most favorable attributes to be met with a positive WTP of US$98, to be compared with the average cost of US$61 (based on figures provided in the interviews). Out of the 25 variants described, only three hip protectors have positive average WTP. Since these variants are not available at present, inclusion of one of the existing models among the mandatory benefits of social health insurance cannot be recommended unless one is prepared to claim that the use of a hip protector generates important positive externalities. Such externalities may derive from net savings generated by those (few) insureds who by wearing the hip protector avoid costly hospitalization. These savings result in premium reductions for the remainder of the insureds.

Table 5.5 Willingness-to-pay for a hip protector in US$

	WTP for a hip protector	Attributes of hip protector (PROT/ HAND/ COMF)
mean over all protectors	-155.66	79/ 2/ 2
maximum WTP	97.52	100/ 3/ 3
minimum WTP	-515.79	50/ 1/ 1

The negative WTP observed raises the issue of future product development and provision of information to potential users. As can be gleaned from Table 4.2, one increment on the scale of COMF (4 levels) is worth US$151 (=0.6628/0.00293 in Swiss francs, exchange rate 1.50). In the case of 'ease of handling' (HAND), this figure amounts to US$76. For ensuring comparability, PROT (range 0, 100) has to be increased by 25 points, which is worth US$80. Therefore, assuming equal productivity of R&D efforts, these efforts should be directed at improved wearing comfort. Also, information about improvements in this attribute may prove of particular importance for encouraging the purchase and use of hip protector.

Conclusion 5.2: The extrapolation from MWTP to WTP results in predominantly negative values for the great majority of hip protectors. Thus, abstracting from the possible external effects of a fracture of the femur, inclusion of the product in the benefit package of social health insurance cannot be advocated.

5.3 Out-of-sample test

An out-of-sample test was performed by applying the estimation results of basic model to roughly 2,000 purchase decisions not used in the estimation. As shown in Table 5.6 below, it was possible to predict stated intentions to purchase correctly in 84.2% of all cases and stated intentions not to purchase, even in 97.9% of all cases. This suggests the specification tests performed were not seriously misleading due in particular to problems of overfitting. More generally, this high degree of accuracy supports the notion that conjoint analysis may have some merit as a method for measuring willingness-to-pay for both marginal variations of product attributes and for the product as a whole. It may be worth emphasizing once more that in the present context, respondents were asked to trade off risk reductions against several (rather than just one) other product attributes.

Table 5.6 Out-of-sample test of the estimated final model

	Actual	Predicted	in percent
Intention to purchase	366	308	84.2
Intention not to purchase	1763	1727	97.9
Intention to purchase (in percent)	17.19	15.14	

Conclusion 5.3: The stability of results obtained from an out-of-sample test confirms the usefulness of conjoint analysis as a method for measuring willingness-to-pay for risk reduction even when traded off against several other product attributes..

6 Discussion and conclusion

As is well known, individuals have difficulties when dealing with probabilities. This implies that measuring the marginal willingness-to-pay (MWTP) for a reduction of risk involving a changed probability may pose a particular challenge, especially when weighed against several other product attributes. In this paper, an attempt is made to determine MWTP for a hip protector that promises to considerably reduce (and even eliminate) the risk of fracture of the femur. This investigation faced a few additional challenges. First, the individuals concerned probably are not only interested in the aspect of risk reduction but may consider other aspects of the preventive effort involved, such as the discomfort caused by wearing such a protector. Second, such a protector being a novel product, there was little guidance with regard to the choice of the relevant product attributes beyond risk reduction. Third, the population at risk is of high age, which may be considered an obstacle to a consistent expression of individual preferences. Fourth, social insurance benefits being very comprehensive in Switzerland (as in most industrial countries), it is not evident that it is possible to elicit expressions of actual willingness-to-pay (WTP). Applications of conjoint analysis with risk reduction included among several product attributes have been few to this date. Given this background, an application of conjoint analysis to the valuation of a risk reduction while controlling for other product attributes may be of some particular interest.

In this study the relevant product attributes were established in a pretest and the choice checked once more in the field survey. The relevant attributes turned out to be protective effect, ease of handling, wearing comfort, and out-of-pocket cost. Conjoint analysis requires respondents only to indicate whether they prefer one scenario over another. Moreover, it was possible to use the status quo as the reference scenario, permitting to couch this ranking in terms of a decision to purchase the product. These features contributed to keep the rate of refusals to participate in the interview low, resulting in a usable sample of some 500 interviews. Based on random utility theory, a binary purchase decision equation was specified and estimated using probit. Several tests were performed w.r.t. the scaling of the attribute variables, the linearity of the utility function used, and the derivation of a final model. All product attributes proved statistically significant in the purchase equation, and MWTP for risk reduction was consistently positive. Theoretical predictions were confirmed to a considerable degree in that individuals exposed to a higher initial risk and having higher income may exhibit a greater MWTP for risk reduction.

Extrapolating from MWTP, a willingness-to-pay for hip protectors as a whole could be estimated. However, only 3 out of the 25 variants distinguished evoked a positive WTP, while mean WTP is substantially negative (some US$-156 evaluated at the mean levels of attributes). This estimate proves to be reasonably robust to the choice of specification of the statistical model.

The policy implication of these findings are clear. While individuals are interested in risk reduction in the context of fracture of the femur, they are willing to trade this off against other product attributes, specifically against wearing comfort in the case of a hip protector. Indeed, it was possible to identify 'wearing comfort' as the attribute with the highest MWTP, exceeding that for risk reduction. However, most product variants available do not offer a sufficient amount of comfort to be met with positive WTP for the product as a whole. This also implies that even if given a protector free of charge, recipients would be unlikely to actually use it. This militates against the inclusion of the device as part of the benefit package prescribed by social health insurance, unless one is prepared to credit it with important positive externalities.

The major result of the study is the applicability of conjoint analysis in a setting fraught with considerable difficulties. There is evidence that risk reduction can be included among a whole set of product attributes and that respondents are able to express trade-offs against several attributes through their purchase decisions. This commends conjoint analysis for research in health economics, where frequently new products with additional product attributes become available, and which may to be traded off against the primary objective of reduced health risks.

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